What is (a) science?

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(Sarah Tietz)

In "The Ends of Sciences", Kitcher sets out to show that the whole scientific context – including the so-called "context of resolution" – is socially embedded and therefore value-laden. I propose to use his line of argument in order to address a different question, namely: What is (a) science?

Considering the diversity of sciences, there do not seem to be many candidates that could figure as an explanatory factor for all of them. However, one candidate does appear rather promising. I am thinking of the end or goal of sciences. Thus, it does not seem far-fetched to assume that, among all the different goals of all sciences, there is at least one that is shared by all of them. To be sure, there are not very many candidates, for the diversity of sciences is reflected in their different goals. Yet, truth seems to represent one candidate that could be the goal common to all sciences. Sciences seek truth. However, its obvious character notwithstanding, truth cannot figure as the common goal for all sciences, for, as Kitcher rightly points out, the slogan "'Seek truth!' is plainly incomplete."[1] First of all, a question has to be framed. Only then is "the goal of finding a true answer … a sensible one."[2] That is, there are always significant types of truth that sciences look for. Thus, the question is whether there are types of truth that all sciences look for. In fact, such types of truth do indeed seem to be available. For, sciences seek the possibility of prediction and intervention in broad areas. Accordingly, they need statements that explain different special cases as instances of a common type. Therefore, it seems, sciences need natural laws. We could say, then, that the goal of sciences is not the search for truth, for this is too general, but the search for distinctive truths, namely natural laws.

However, it cannot easily be taken for granted that natural laws are indeed the goal of all sciences. For, as is well known, there are many sciences such as history, political sciences, philosophy, and even natural sciences such as biology the findings of which do not take the form of natural laws. This fact, however, need not be an argument against the thesis that sciences aim at finding natural laws. For, one could say that those disciplines that do not or cannot share this end simply do not count as sciences; and for disciplines

[1] P.K., "The Ends of Sciences", p. 9.
[2] Ibid.

such as philosophy, sociology or literature, there are numerous scholars who do indeed share this opinion.

However, this opinion might be nothing but mere stipulation. What we need is a separate argument, one that shows why it is only the quest for natural laws that qualifies a discipline as a science. Yet there is also a different strategy: in order to examine the thesis that only those disciplines that aim at finding natural laws can be counted as sciences, we could take a look at and evaluate the (tacit) assumptions behind it. Kitcher points out the following: on the one hand, "it supposes that there's some general project of understanding nature," and on the other hand, "it assumes that there's some manageable collection of laws that can be appreciated by human beings (or by recognizable idealization of ourselves) and that will make possible the general project."[3] These two assumptions go together with a third, which is almost trivial: at least one science is needed that has the collection of natural laws as its main goal. If other disciplines, those the generalizations of which do not take the form of natural laws, are to count as sciences, too, then they would better be reducible in one way or another to this special science. One science that aims at discovering natural laws is, of course, physics. Accordingly, physicalism would be the position to be held.

All three assumptions, however, present well-known difficulties. Thus, first of all, after the appearance of "There is no Question of Physicalism" by Crane and Mellor, at the latest, physicalism seems to be no longer tenable.[4] For, physicalism faces the following dilemma: Who decides what is to count as a physical object? An obvious answer is, of course, physicists; but which physicists do we mean: are these the exponents of the current, or of an idealized, complete, future physics? If the first are meant, then physicalism is presumably false. For, it is not very likely that present-day physics has identified all physical entities. If, however, an idealized, complete future physics is meant, then physicalism amounts to something trivial. After all, an idealized and complete physics would necessarily pick out all basic entities, of whatever kind they might be. Yet, how are we to exclude the possibility that, among these basic entities, there are also numbers or qualia, entities that, as far as we know, are not objects of natural laws?

Moreover, there are other problems. Indeed, if it were possible for the sciences both "to fall into a finite number of clusters, each of which can be subsumed under a finite number of basics laws" and to "extend beyond the areas of inquiry that have so far emerged in the actual history of the sciences to cover all the phenomena", the assumption

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[3] Ibid. P. 11.

[4] T. Crane, T.H. Mellor 1990: "There is no Question of Physicalism", *Mind* 99, pp. 185-206.

that there is some collection of laws that can be appreciated by human beings (or by a recognizable idealization of ourselves) and that will make possible the general project of understanding nature could be sustained.[5] Yet, as Kitcher rightly remarks, “once the unity-of-science picture has been discarded, there’s no basis for thinking that the clusters of laws (even assuming we can always find them) won’t proliferate indefinitely.”[6]

The third and last problem presented by these assumptions lies in the idea of some general project of understanding nature. For, the slogan “Understand nature!” is as incomplete and as meaningless as the slogan “Seek truth!”[7] Also: what is meant by “nature”? It is obvious that attempts to answer this question present the same dilemma as physicalism.

Therefore, it seems we have good reasons to abandon the thesis that only those disciplines whose goal is the discovery of natural laws can count as sciences. Do we have another goal, then, that could characterize all the sciences? Kitcher makes one more suggestion. Sciences, so he claims, have a common ideal: they all aim at unity. Against all appearances, however, this is not a proposal for a lapse back into the unity-of-science movement: for Kitcher as well, there is and can be no unity of science. Nevertheless, he claims, sciences reflect a regulative ideal, namely “the ideal of finding as much unity as we can by discovering perspectives from which we can fit a large number of apparently disparate empirical results into a small number of schemata.”[8] Thus, sciences exemplify what Kitcher calls a “modest unificationism”. This unificationism is modest in at least two ways: on the one hand, as just, seen, it keeps in mind, that sciences cannot be unified for the reasons mentioned in the beginning. Therefore, on the other hand, this unificationism allows for different unifying schemes for explaining and predicting various aspects of nature, schemes, that “aren’t integrable into any overarching grand theory.” (347). What holds all sciences together, therefore, is not that they are reducible to one special science but that they are all modest unificationist. All sciences aim at unification. Unification is their a regulative ideal.

In what follows I want to question this idea. Using the example of the relatively new discipline of evolutionary-developmental biology I want to suggest that unification should not be understood as an aim in itself but rather as a method. Unification, or the

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[5] Kitcher, p. 13.
[6] Ibid.
[7] Ibid., p. 14.
[8] Kitcher 1999: “Unification as a Regulative Ideal”, *Perspectives on Science*, vol. 7, no.3, p. 339.

combination of disciplines or theories, or so I want to argue, is a method whose application depends on the problem pursued.

First of all, a few words on evolutionary-developmental biology, short: evo-devo. As the words already suggest, evo-devo is a recent attempt to integrate the long separated disciplines of evolutionary biology and developmental biology again. The reason is that apart from explaining adaptation and speciation there are other questions about evolution, such as the question for phenotypic evolvability or the question for the evolutionary origin of body plans and novel structure, that require the involvement of developmental biology. Since genes that are involved in important early developmental events are shared across large groups of animals (mammals and insects, for instance) it seems obvious that phenotypic evolution cannot be explained by merely referring to specific changes in genes. What seems to be of higher impact, therefore, are evolutionary changes in how the activation of genes is regulated. In spite appearances to the contrary, evo-devo should not be seen as a simple synthesis of evolutionary and developmental biology with developmental genetics providing the link. For, many evo-devo problems such as accounting for the origin of novel structures require integrating knowledge from many different disciplines, such as phylogeny, population genetics, palaeontology, morphology, theoretical biology, ecology, and developmental genetics.

Now, how and, above all, why are all these disciplines integrated? Let us take a look at the explanation of evolutionary novelties. An evolutionary novelty is understood as a qualitatively new morphological structure or function feature in a group of organism that did not exist in an ancestral species. Examples here are the vertebrate jaw, feathers and flight in birds, the turtle carapace, and paired fins in fish and their transformation into limbs in amphibians. What seems clear is that for an explanation of these novelties phylogeny is of high relevance. For, what is needed is a determination of the particular phylogenetic junctures at which characters were transformed and novelties arose in evolution. Thus, any explanation of the origin of novelties needs phylogentic trees. Now, these trees usually were based on an analysis of classical characters, such as morphological structures. But nowadays they are also inferred from molecular data, such as gene sequences. Thus, the problem is to integrate both approaches. This all the more since there are several cases where each supports a different phylogeny. Despite attempts of combining both kinds of data (by so-called total evidence approaches), there are currently no generally agreed upon methods of determining how to weigh the contribution of classical and molecular information. However, both approaches are important in order to explain novelties. This holds as well for palaeontology which adds a historical-temporal scale to phylogenies. Palaeontology lays out the ancestral states of characters and structural intermediates (if any) up to the state in the descendant. On that basis it can suggest the particular morphological changes that constitute the origination of the novel feature. In this context ecology and biogeography get importance. For they help explaining how transitional character states in the emergence of a novelty could have been compatible with or positively favored by natural selection. And they help explaining how the evolution of this character relates to changes in geographical and ecological conditions that the species underwent. But here again, we have to levels of explanation: the microevolutionary level of neo-Darwinism that focuses on change in gene frequencies within a species and the macroevolutionary level of large-scale trends involving many species, such as extinction rates and patterns, the formation of higher taxa, and the mode and tempo of morphological evolution in several related lineages. But here again, both levels have to be integrated. For while the advent of major novelties (such as the evolution of limbs) or whole body plans involves macroevolutionary events, at the same time it has to be made plausible how the advent of a phenotypic novelty can be consistent with modes of genetic change within populations. But why, or so one might ask, is neo-Darwinian evolutionary theory with its use of population genetics not in a position to account for the origin of novelties, all by itself? One reason is that neo-Darwinism explains phenotypic change based on natural selection acting on existing heritable phenotypic variation. This, however, does not explain why the phenotypic variation could have been produced in the first place. Of course, it has been known for a while what mechanisms produce genotypic variation. But this is not the question to be answered in this context. The crucial question in this context is how genotypic variation translates into *phenotypic* variation – and those questions are in the domain of developmental biology.

Another reason is that, while genetic variation is produced in a largely random and unbiased fashion, this does not apply to the thereby generated phenotypic variation. Some phenotypic variants are developmentally impossible. Among the possible variants some are more likely to occur than others. Thus there is a *developmentally* grounded bias in the amount of heritable phenotypic variation generated. Furthermore, many novelties seem to involve a breaking up of developmental or functional constraints that prevailed in the ancestral lineage. A case in point is the shift from reptilian scales to avian feathers. Both structures may have some common developmental roots, but contrary to previous assumptions feathers did not evolve in a smooth transition from scales. For, feathers are not within the normal mutational range of scales. That is, feathers were governed by certain developmental constraints. Therefore, an account of novelties has to explain first, how ancestral developmental constraints could have been and were broken thereby leading to the emergence of the novelty, and second, how the new structure was developmentally integrated into other structures.

A third an last reason why neo-Darwinism cannot do without developmental biology is that many novelties are mere by-products of selection, that is, of adaptive evolution. That is, there was no selection *for* certain tissues getting close to each other. In those cases, natural selection is of course causally involved, but it does not carry the explanatory force in the account of novelty.

The moral of it all is, features within organisms must be explanatorily important for the explanation of novelties. Thus, an account of novelties does in fact need knowledge of many different fields, such as phylogeny, paleontology, ecology, biogeography, neo-Darwinism and developmental biology. And of course, knowledge of functional morphology is of importance, as well. For the evolutionary origin of novel structures includes also function features. The case of explaining novelties, as many other cases as well, allows for no reduction to one of the above-mentioned disciplines. One reason is that structures on different levels can sometimes evolve independently of one another. Another is, that the same gene can be involved in different developmental pathways or in the production of non-homologous structures in different species. That means that, first of all, biologists have to find the various natural kinds or units that are relevant for a particular developmental or evolutionary explanation.

The necessary failure of reduction should not lead us to the contrary opinion that evo-devo is just a case of pluralism. The combination of different methods and approaches is not a mere accident. On the contrary, as I tried to show, accounting for the evolutionary origin of novelties makes it necessary to integrate different theoretical models and modes of explanations. Evo-devo needs both microevolutionary theories of population genetics and macroevolutionary models of palaeontology. Both scientific approaches have to be combined in this case. Likewise, explanations of developmental biology and functional morphology have to be integrated with neo-Darwinian modes of explanation. Of course, developmental biology and functional morphology lay out the causes or mechanisms that actually account for the origin of novelty. That is, these disciplines carry most explanatory force. But, and this is the important point, there is nothing intrinsic about both disciplines that makes them explanatory fundamental.

Now, why did I tell you all that? Because I think the example of evo-devo shows that unification is not an aim in itself. That there is no general linear ordering of explanatory more or less fundamental theories or disciplines does not only show that there is no hierarchy among sciences, a fact Kitcher himself argued for, it also shows that the epistemic relations between different approaches are rather complex and, what is of importance, the relative contribution and explanatory fundamentality of each approach *depends on and varies with the particular problem*. And each problem has its own criteria of explanatory adequacy. Thus, what amount of integration or unification is needed depends on those criteria. They set the standards of what shape a satisfactory explanation has to take. By forming the overall explanans for the explanandum these criteria determine which theoretical and/or empirical ideas are relevant for solving the problem. Thus, criteria of explanatory adequacy – together with the specific problem – do not only determine the amount of unification needed, they determine if unification of different methods is necessary at all. Therefore, unification, as I said, is not an aim in itself, but is likely to be needed *for the aim of* solving a complex scientific problem. In contrast to Kitcher`s "ideal of finding as much unity as we can", I recommend the ideal of finding as much unity as scientists need in order to solve a scientific problem.

If I am right, then sciences are not distinguished from non-sciences by having the aim of unification as a regulative ideal. This and the discussion in the beginning suggests then that sciences do not share one common end. And what is more, even a single science does not have specific ends. To put it in the words of Richard Feynman (nobel-prize winner in physics): "Science is like sex. Sure, it may give some practical results, but that`s not why we do it." Thus, sciences are neither ultimately distinguishable by their methods – both from one another and from non-sciences nor by their aims. They do not aim for truth in general, nor for natural laws, nor for unification. What does this mean for my question of what is (a) science? I think it means we have to stick to the in my opinion very unsexy claim that sciences are held together by family resemblances. This allows for variations of scientific standards within history and disciplines, and it allows for an influence of the public in the determination of what is to count as a science. The latter a thing that Kitcher, to my knowledge, embraces.